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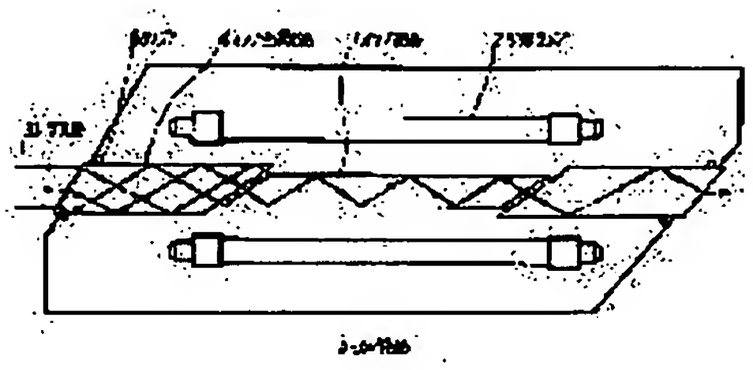
(54) SLAB TYPE SOLID LASER DEVICE

(57)Abstract:
PURPOSE: To provide a device construction in which the light axis adjustment is easy, the laser oscillation efficiency is high, and the device can be prevented from becoming large-sized, and a device construction in which parastitic oscillations can be prevented or controlled in a solid laser device using a plate- like laser medium which has a pair of opposing plate surfaces as excitation surfaces for receiving pumping light.
CONSTITUTION: On both sides of a solid laser medium 1 in the optical direction thereof, slab-type light guiding paths 4 is so provided that their optical axes are aligned. The angles of the incidence surface and reflection surface are so determined that laser a light incident along the optical axis is outputted in a direction in which there is no area in which laser light is not optically excited in the solid laser medium 1, a region other than the region of the opposing plate surfaces upon which normal laser light is incident is formed in an incident light amount reducing region in which the amount of light incident on the laser medium other than the normal laser light is reduced.



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* NOTICES *

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the slab mold solid-state-laser equipment using the tabular solid-state-laser medium which has one pair of plate surfaces which counter as an optical-pumping side which receives excitation light.
[0002]
[Description of the Prior Art] If the laser beam way 3 which makes the tabular slab mold solid-state-laser medium (henceforth a slab crystal) 1 which has one pair of plate surfaces 1A and 1A as an optical-pumping side which receives the exposure of excitation light carry out incidence of the laser beam to an optical-pumping side at parallel is set up with conventional slab mold solid-state-laser equipment as shown in drawing 7 The field 11 through which a laser beam does not pass in the slab crystal 1 is generated, and the excitation light absorbed by this field does not contribute to laser oscillation, but produces loss of excitation light energy at this rate. The close outgoing radiation end face of the laser beam of the slab crystal 1 used the tilt angle as the Brewster angle of incidence in many cases, in order to make it not produce reflection loss without carrying out antireflection-film coating, but since the excitation loss field 11 existed even if it abolishes the reflection loss of the close outgoing radiation end face of the slab crystal 1, it had become the obstacle of the improvement in laser oscillation effectiveness of slab mold solid-state-laser equipment, or high-power-izing on the laser beam way 3 parallel to an optical-pumping side of the slab crystal 1 like drawing 7 .
[0003] Moreover, although there is an approach only an include angle theta leans the laser beam way 3 to the optical axis of the slab crystal 1 as shown in drawing 8 in order to lose the excitation loss field 11 There is an excitation lamp 2 which irradiates the optical-pumping sides 1A and 1A in the upper and lower sides of the slab crystal 1. In order to start the laser beam way 3 near the edge metallic ornaments of this excitation lamp 2, and for there to be a problem that incidence of the whole quantity of the laser beam which spreads the laser beam way 3 cannot be carried out to the slab crystal 1 and to solve this problem The method of allotting the slab light guide line 12 to the direction both sides of an optical axis of the slab crystal 1, and carrying out incidence of the whole quantity of a laser beam to the slab crystal 1 like drawing 9 , is proposed (refer to JP,4-12579,A).
[0004]
[Problem(s) to be Solved by the Invention] However, since a laser beam way becomes slanting to the optical axis of a slab crystal as mentioned above also by the approach of allotting a slab light guide line to the direction both sides of an optical axis of a slab crystal in order to lose the excitation loss field in a slab crystal If the laser beam way 3 of the entrance of the container 5 (drawing 9) which contains a slab crystal shifts in parallel, is formed on both sides of a container 5 and constitutes laser equipment combining a total reflection mirror and an output mirror, the problem that optical-axis adjustment is difficult will produce it. Moreover, there is a problem that equipment tends to become large-sized since the light guide line 13 which constitutes the laser beam way 3 becomes slanting to the optical axis of the slab crystal 1 and the slab light guide line 12, and processing becomes complicated.

[0005] Moreover, if such a slab light guide line 12 is formed, possibility that the oscillation with various directions of light will arise using the reflector of the laser beam which one pair of opposite plate surfaces of this light guide line form will arise. This is called parasitic oscillation. In drawing 13 , a beam of light 21 shows the medial axis of a normal light which is resonating, and beams of light 22 and 23 show the edge of the upper and lower sides of the bundle of rays of a normal laser beam. However, if incidence of a different beam of light from the laser beam with a normal direction which enters in a beam of light 22 and the width of face between 23 in the close injection section of a stowage container 5, for example, a beam of light like 24, is carried out This beam of light is reflected by the opposite plate surface of a light guide line, it goes into the slab crystal 1, this receives excitation luminous energy, it is injected as an abnormality light of high energy outside, and a problem arises in respect of the increase of loss of laser equipment, and safety.
[0006] Since a direction will change and re-incidence will be carried out if near, although only loss of the reflected light is required since the reflected light will not go into a light guide line if it is generated when such a beam of light has curvature for example, in a resonance mirror (drawing 14 , signs 18 and 19) and it reflects by the resonance mirror, and there are resonance mirrors of enough far away from a stowage container 5, the equipment engine performance is reduced with loss of excitation light as mentioned above, and the problem of safety arises.
[0007] It solves an above-mentioned problem, and optical-axis adjustment is easy for the purpose of this invention, and it is offering the equipment which does not make an excitation loss field in a slab crystal, and further the equipment that parasitic oscillation's also controls [prevention or], without enlarging equipment.
[0008]
[Means for Solving the Problem] The equipment formation which does not make an excitation loss field in a slab crystal, without optical-axis adjustment being easy and enlarging equipment first in this invention among the above-mentioned technical problems sake, The slab mold solid-state-laser equipment using the tabular solid-state-laser medium which has one pair of plate surfaces which counter as an optical-pumping side which receives excitation light On direction both sides of an optical axis of a solid-state-laser medium, and the laser beam which this optical axis and the optical axis were made in agreement, and carried out incidence in this optical axis and this direction from the exterior While being able to determine whenever [to an optical axis / tilt-angle], plane of incidence and a injection side, respectively, so that it may inject towards the direction end face of an optical axis of a solid-state-laser medium in the direction where the field where a laser beam does not receive optical pumping does not exist, and the becoming direction within a solid-state-laser medium It considers as the equipment with which the slab mold light guide line in which the light guide line between this plane of incidence and a injection side was formed as a total reflection way where the optical-pumping side and the direction of a field of a solid-state-laser medium have one pair of total reflection sides of this direction is allotted.
[0009] It is suitable if it is made not to exist in a plane-of-incidence side from the incidence side edge section of the total reflection side where the total reflection side which produces the 1st total reflection after the incidence of a laser beam here among one pair of total reflection sides which constitute the total reflection way of a slab mold light guide line is kept away from the die-length range [some] and total reflection side side which counters covering the overall length of the plane-of-incidence side edge section to the direction of an optical axis , and the 1st total reflection point counters .
[0010] Furthermore, it is still more suitable if the cross-section configuration of the total reflection way of optical-axis lay length within the limits of the total reflection side of the direction which produces the 1st total reflection kept away from the total reflection side which counters is made into an ellipse. Furthermore, after the incidence in the total reflection way of a slab mold light guide line, if it forms in the flange of the transverse-plane configuration round shape which made the diameter the magnitude which can connote the cross section of a total reflection way which makes the field which has the tilt angle of plane of incidence for a plane-of-incidence side an incidence side edge side, it is very more suitable than the 1st total reflection point.
[0011] For the equipment formation in which prevention of parasitic oscillation or control is possible

among the above-mentioned technical problems, moreover, in this invention The slab mold solid-state-laser equipment using the tabular solid-state-laser medium which has one pair of plate surfaces which counter as an optical-pumping side which receives excitation light On direction both sides of an optical axis of a solid-state-laser medium in agreement in this optical axis and an optical axis -- making -- fields other than the normal laser beam exposure field of an opposite plate surface -- this -- it considers as the equipment with which the light guide line of the shape of average configuration slab currently formed as an amount reduction field of incident light which reduces the amount of incidence into the solid-state-laser medium of the light of a different direction from the average travelling direction of a normal laser beam was allotted.

[0012] Here, if the amount reduction field of incident light of a light guide line opposite plate surface is formed as a scattered reflection side of light, it is very suitable. Moreover, the amount reduction field of incident light is formed as a way inclination reflector, while inclining in the other party's direction of an opposite plate surface from a normal laser beam exposure field edge, or you may make it form as an other party opposite plate surface and a photoconductive appearance reflector which has a light reflex side to the field which kept away to the opposite direction from the laser beam exposure field where the amount reduction field of incident light is normal.

[0013] In considering as a photoconductive appearance reflector, form a photoconductive appearance reflector as the other party's opposite plate surface and a method inclination reflector of outside to which it inclines to an opposite direction from the normal laser beam exposure field edge of a light guide line opposite plate surface, or and to a normal normal laser beam exposure field side and parallel in a completely different class from a laser beam exposure field edge Or it is good to make it form as a reflector in a completely different class which inclines toward the other party's opposite plate surface and opposite direction, and extends in a normal laser beam travelling direction.

[0014] In addition, the photoconductive appearance reflector is suitable if it is made to form using the member different from a light guide line which has a refractive index more than the refractive index of light guide line material.

[0015]

[Function] If slab mold solid-state-laser equipment is constituted as mentioned above, by the equipment configuration for the 1st technical problem (easy-izing of optical-axis adjustment etc.), processing of the container which the medial axis of a laser beam way, the optical axis of a slab mold light guide line, and the optical axis of a slab crystal are in agreement, and adjustment of an optical axis becomes easy, and equipment is miniaturized, and contains a slab crystal will become easy first. How to decide whenever [each tilt-angle / of the plane of incidence of a slab mold light guide line and the injection side which make this possible] is explained below.

[0016] The configuration of the slab mold light guide line (it abbreviates to a light guide line below) of this invention is shown in drawing 6 . Drawing 6 is drawn as what has a slab crystal in right-hand side. Between a light guide line and a slab crystal, it is a refractive index n3. The medium shall be filled. Moreover, it is the refractive index of the medium on the left of n2 and a light guide line about the refractive index of a light guide line n1 It shall carry out and the medial-axis line which is the optical axis of a light guide line shall be in agreement with the optical axis of a slab crystal. The direction, then this direction P of the laser beam injected from the slab crystal side edge side of a light guide line the sign P in drawing Since it is beforehand given into a slab crystal as a direction which does not produce an excitation loss field when a laser beam carries out incidence to a slab crystal slab crystal edge face angle [of a light guide line] whenever thetaB if it sets up suitably -- angle-of-emergence thetai naturally -- being decided -- incident angle thetao to this end face Snell's-law: -- n2 sin thetao =n3 sin thetai from -- it can ask and, thereby, angle-of-reflection thetaalpha in a total reflection side can be found. Incident angle thetagamma to, carry out incidence of the laser beam which carries out incidence to the total reflection side of a light guide line at parallel to ** from which angle of reflection becomes thetaalpha in a total reflection side on the other hand to the slab crystal of a light guide line and the end face (plane of incidence) of the opposite side is n1 by the Snell's law. sin theta gamma=n 2 It is tilt-angle thetaA of an end face so that it may be set to sin thetabeta. What is necessary is just to give. Specifically, it is n1. sin

theta gamma=n 2 It asks for thetagamma using two formulas, sin thetabeta and theta gamma=theta beta+theta alpha, and the tilt angle of an end face can be found as thetaA =pi/2-thetagamma.
[0017] Thus, tilt-angle [of light guide line plane of incidence] whenever thetaA, especially angle-of-reflection thetaalpha of a total reflection side are tilt-angle [of a injection side] whenever thetaB. Since it is depended and decided, it is thetaB. It changes and they are angle-of-reflection thetaalpha and plane-of-incidence tilt-angle thetaA. Asking, when making it the overall length of the direction of an optical axis of a light guide line become the shortest, a miniaturization becomes possible from that of equipment. In this case and the plane of incidence of a slab crystal Since it becomes unnecessary to hold a brewster's angle to the incident light of the direction of an optical axis of a slab crystal, already By making it approach as much as possible with the injection side of a light guide line, as it becomes the injection side of a light guide line, and parallel It will ask [while preventing attenuation of the laser beam by the medium (indifferent water) for which it depends among both sides, and] for whenever [tilt-angle / to which the overall length of a light guide line becomes the shortest], setting up the direction of incidence of a laser beam where an excitation loss field does not exist.
[0018] Moreover, the inside of one pair of total reflection sides which constitute the total reflection way of a slab mold light guide line, The total reflection side which produces the 1st total reflection after the incidence of a laser beam is crossed to the overall length of the direction of an optical axis from the plane-of-incidence side edge section. Or if it is made not to exist in a plane-of-incidence side from the plane-of-incidence side edge section of the total reflection side where it keeps away from the die-length range [some] and total reflection side side which counters, and the 1st total reflection point counters The O ring used for the festival which attaches a light guide line in a slab crystal stowage container watertight as a watertight sealant can be placed into a flat surface perpendicular to an optical axis, the location after an equipment assembly is stabilized, and maintenance of a watertight function becomes easy.
[0019] Furthermore, if the ellipse of the cross-section configuration of the total reflection way of optical-axis lay length within the limits of the total reflection side of the direction which produces the 1st total reflection kept away from the total reflection side which counters is carried out, since an angle will be lost on the light guide line front face which mates an O ring, the life of an O ring can be developed. After the incidence in the total reflection way of a slab mold light guide line, from the 1st total reflection point furthermore, a plane-of-incidence side If it forms in the flange of the transverse-plane configuration round shape which made the diameter the magnitude which can connote the cross section of a total reflection way which makes a field with the tilt angle of plane of incidence an incidence side edge side, watertight processing of a slab crystal stowage container will become the easiest. Process tolerance improves by this, the watertight engine performance becomes the highest and the dependability of equipment improves.
[0020] Moreover, in the equipment configuration for the 2nd technical problem (prevention or control of parasitic oscillation), if the energy when being injected even if optical pumping is carried out within a laser medium, since the quantity of light of the abnormality light by which incidence is carried out into a laser medium is reduced is small and this is absorbed in an edge strip, parasitic oscillation will become difficult. Moreover, since energy is small, it is hard coming to also generate the problem of safety.
[0021] Then, if the amount reduction field of incident light of a light guide line opposite plate surface is formed as a scattered reflection side of light, since scattered reflection of the abnormality light is carried out, the amount of incident light into a laser medium will decrease sharply. In addition, solution of a technical problem is possible for a scattered reflection side, without formation being easy and accompanying it by cost rise of equipment substantially by sand shearing processing, sandblasting, chemicals processing, etc.
[0022] Moreover, since the abnormality light which carried out incidence of the amount reduction field of incident light to formation, then this field as a way inclination reflector while inclining in the other party's direction of an opposite plate surface from the normal laser beam exposure field edge separates from the optical axis of a laser medium greatly and advances, how to receive excitation light energy becomes small, and it cannot result in parasitic oscillation easily. Moreover, an inner direction

inclination reflector can solve a technical problem like [since it can form by carrying out grinding of the outside of the opposed face of a slab-like object, formation is easy, and] the case where it is scattered reflection side formation, without being accompanied by the rise of substantial equipment cost.
[0023] Moreover, if it is made to form as an other party opposite plate surface and a photoconductive appearance reflector which has a light reflex side to the field which kept away to the opposite direction from the laser beam exposure field where the amount reduction field of incident light is normal, since the abnormality light which carried out incidence to this field will be injected in the exterior of a laser medium, prevention of parasitic oscillation becomes more certain. Moreover, a photoconductive appearance reflector in this case from the normal laser beam exposure field edge of a light guide line opposite plate surface [whether it forms as the other party's opposite plate surface and a method inclination reflector of outside to which it inclines to an opposite direction, and] Since it can form as a reflector in a completely different class which inclines toward a laser beam exposure field side normal in a completely different class from a normal laser beam exposure field edge, the opposite plate surface of parallel or the other party, and an opposite direction, and extends in a normal laser beam travelling direction Since a reflector can be formed using standardized another member, without being able to fix another member on a slab-like object, being able to perform formation of a photoconductive appearance reflector, and processing it into a slab-like object, facilities are obtained by working planes, such as handling of a member.
[0024]
[Example] The 1st example of this invention is shown in drawing 1 . The slab crystal 1 performs geometric design so that the reflective loss of an end face may serve as zero because a laser beam carries out incidence into a crystal by the brewster's angle, and so that an excitation loss field may not be generated in the laser crystal 1. The excitation luminous energy absorbed from the excitation lamp 2 is consumed by laser oscillation without futility by this, it can be efficient and a laser beam can be generated. Although the laser beam which carries out incidence to one side of the direction both-ends side of an optical axis of the slab crystal 1, and is injected from another side is slanting to the optical axis of the slab crystal 1 By installing the light guide line 4 calculated by the term of the preceding clause [an operation] by drawing 6 like a publication in the direction both sides of an optical axis of the slab crystal 1, the medial axis of the laser beam way 3 of the exterior of the laser medium stowage container 5, the optical axis of a crystal 1, and the optical axis of a light guide line 4 are in agreement. Since an excitation lamp 2 and the slab crystal 1 generate heat, he sinks these both completely inside the laser medium stowage container 5, and is trying to cool in this example. In order to lessen attenuation of the laser beam by the water which exists between the slab crystal 1 and the light guide line 4 of both sides, thetaB (drawing 6) considers as the same include angle as whenever [edge face angle / of the slab crystal 1], and is making the light guide line 4 and the slab crystal 1 approach as much as possible whenever [by the side of the slab crystal 1 of a light guide line 4 / edge face angle]. Moreover, in an O ring, although O ring 6 for seals is used for the seal of the water of the laser medium stowage container 5, the laser beam of the zigzag reflection of the light guide line 4 interior is installing O ring 6 for seals in the part which the laser beam way 3 does not pass aslant so that an O ring member may not be damaged by fire.
[0025] Drawing 2 shows the 2nd example of this invention. Although the seal of water is not necessarily easy, when it must install O ring 6 for seals aslant in the light guide line configuration of drawing 1 , and the light guide line 7 of drawing 2 keeps away the reflector of the medial-axis line bottom below moderately The laser beam reflective location of a lower total reflection side can be shifted to the method of the right from the left end side of a light guide line, the field through which the laser beam way 3 does not pass is expanded, and it enables it to install this O ring 6 for seals in a field perpendicular to the medial-axis line of a light guide line. By carrying out like this, the location of the O ring after an assembly is stabilized and the seal function of water can be stabilized.
[0026] Drawing 3 shows the 3rd example of this invention, and the light guide line 7 of a publication is made for the seal of water to become easy further at drawing 2 . It can be made to perform considering as an ellipse, as this example shows to drawing 3 , in order to make the seal of water easy, although the

rectangle of the light guide line 7 given in drawing 2 is sufficient as an A-A cross-section configuration and not being specified especially, mating O ring 6 densely on the periphery of a light guide line, and setting easily.

[0027] Drawing 4 and drawing 5 show the 4th example of this invention. In this example, a light guide line 9 processes a cylindrical light guide line member so that a cylindrical side-face configuration may become T typeface, and the vertical-line part of T characters is formed in a total reflection side, and it forms the striping part in the flange of a transverse-plane configuration round shape. It is formed in a slant face with the tilt angle of the plane of incidence by this invention, and the end face at the right end of a total reflection side is formed in a slant face with the tilt angle of the injection side by this invention, and the left end side of a flange is arranged so that the medial-axis line for a total reflection surface part may be in agreement with the optical axis of a slab crystal. Since the light guide line cross section of O ring seal part becomes circular like drawing 5 by forming a light guide line 9 in this way, watertight processing of a slab crystal stowage container becomes easy, process tolerance improves by this, and the watertight dependability of equipment improves. Moreover, since the seal part is distant from the laser beam way 3 enough, a laser beam does not shine upon an O ring and an O ring member does not damage it by fire.

[0028] In addition, the light guide line of this invention can be applied, even if the tilt angle of the plane of incidence of a slab crystal is not a brewster's angle to the incident light of the direction of an optical axis of a crystal, and also when the slab crystal has not sunk in the stowage container. The 5th example of this invention is shown in drawing 10 . This example is a thing aiming at prevention or control of parasitic oscillation, and shows the equipment configuration which arranged what made the non-irradiating field of normal laser the scattered reflection side among one pair of opposite plate surfaces as a slab mold light guide line at the direction both sides of an optical axis of the slab crystal 1. The sign 14 in drawing is a scattered reflection side, and is formed of sand shearing processing.

[0029] The 6th example of this invention is shown in drawing 11 . In this example, the non-irradiating field of a normal laser beam is formed in an inner direction inclination reflector among one pair of a slab-like light guide line of opposite plate surfaces for parasitic oscillation prevention or control. Since the abnormality light which carried out incidence to this reflector is reflected in the direction which separates from the optical axis of the slab crystal 1 greatly compared with the former, parasitic oscillation stops being able to happen very easily.

[0030] The 7th example of this invention is shown in drawing 12 . This example shows what established the external derivation reflector 16 of abnormality light in the light guide line thickness direction outside of the non-irradiating field of a normal laser beam among one pair of a slab-like light guide line of opposite plate surfaces. This external derivation reflector consists of the transparent quality of the material with the refractive index more than the refractive index of a light guide line 12, and is formed as an inclined plane of the block 17 of a cross-section trapezium stuck on the outside of the opposite plate surface of a light guide line. Since the refractive index of block 17 is large, it reflects in the reflector 16 which was bent and inclined toward the method of outside more in respect of attachment, and the light which carried out incidence to this field is drawn outside.

[0031]

[Effect of the Invention] As stated above, it sets to this invention. Slab mold solid-state-laser equipment On direction both sides of an optical axis of a solid-state-laser medium, and the laser beam which this optical axis and the optical axis were made in agreement, and carried out incidence in this optical axis and this direction from the exterior While being able to determine whenever [to an optical axis / tilt-angle], plane of incidence and a injection side, respectively, so that it may inject towards the direction end face of an optical axis of a solid-state-laser medium in the direction where the field where a laser beam does not receive optical pumping does not exist, and the becoming direction within a solid-state-laser medium Since it considered as the equipment with which the slab mold light guide line in which the light guide line between this plane of incidence and a injection side was formed as a total reflection way where the optical-pumping side and the direction of a field of a solid-state-laser medium have one pair of total reflection sides of this direction is allotted While the exposure of a slab crystal is attained by

excitation light covering the direction overall length of an optical axis The excitation loss field from which a laser beam does not receive excitation within a slab crystal even if it carries out incidence of the laser beam along the laser beam way which was in agreement with the optical axis of a slab crystal is lost, the whole quantity of the excitation light absorbed by the slab crystal contributes to laser oscillation, and the laser oscillation effectiveness of equipment improves. Moreover, since all of both the opticals axis of a slab mold light guide line and a slab crystal and the optical-path medial axis of the close outgoing radiation laser beam to a slab mold light guide line are in agreement, while optical-axis adjustment of equipment becomes easy, a slab crystal and the container which contains a slab mold light guide line become small, and equipment cost decreases.

[0032] Moreover, since the slab mold light guide line by this invention inclines to an optical axis, plane of incidence Keep away one side of a total reflection side from another side, and by making the total reflection side field which does not receive the exposure of the laser beam which carried out incidence to the light guide line plane-of-incidence side of one total reflection side Or by forming in an incidence side the flange of the transverse-plane configuration round shape which made the slant face with the tilt angle of the plane of incidence by this invention the incidence side edge side The O ring which is a sealant at the time of holding a slab mold light guide line watertight to a slab crystal stowage container can be placed into a field perpendicular to the optical axis of a light guide line. The location of the O ring after an equipment assembly is stabilized, and watertight processing of a slab crystal stowage container can also become easy, and its process tolerance can improve, and it can be used as equipment with high watertight dependability.

[0033] Furthermore, since the amount reduction field of incident light was formed in the slab mold light guide line, prevention or control of parasitic oscillation was attained and the reduction and the improvement in safety in loss of power were attained as equipment.

[Translation done.]